AMERICAN SOCIETY FOR
ENOLOGY AND VITICULTURE

38th Annual Meeting
Anaheim Marriott Hotel & Convention Center
Anaheim, California
June 25-27, 1987

19. MOISTURE STRESS OF CHENIN BLANC WINE GRAPES AS A MEANS OF CONTROLLING BOTRYTIS BUNCH ROT

Gwynn A. Sawyer, Charles F. Krauter, and W. Keith Patterson, Viticulture and Enology Research Center, California State University, Fresno, CA 93740-0089, U.S.A.

During the 1986 season, five treatments through drip irrigation were applied to a mature Chenin blanc vineyard on the CSUF campus. The treatments were designed to induce stress at various phenological stages of the fruit. Stress at critical times in the developmental stage has been shown to cause the formation of smaller berries, and hence a looser cluster. This, in turn, may counteract the cluster's natural compactness and the tendency for bunch rot infections.

Berry weight, titratable acidity, pH, degrees Brix, yield, rot levels and pruning weight data were collected. Stress induced at veraison resulted in significantly lower acidity and higher pH than control or early stress treatments.

Rot levels were determined via analysis of glycerol, acetic acid and ethanol values on a Waters HPLC. Vines stressed at veraison had significantly lower rot values than all other treatments at the 5% level. Additionally, production data showed that yield amounts were not significantly different between treatments. Thus, there was no detectable loss of yield with a concomitant drop in the level of rot for vines stressed at veraison.

P13. WATER STRESS MONITORING OF A CHENIN BLANC VINEYARD UTILIZING PLANT LEAF DATA

Charles F. Krauter, Gwynn A. Sawyer and W. Keith Patterson, Viticulture and Enology Research Center, California State University, Fresno, CA 93740-0089.

Monitoring water stress of vines is important for scheduling irrigations. It may also be part of a cultural practice such as the reduction of bunch rot by the careful induction of stress on varieties such as Chenin blanc under drip irrigation. Methods of stress monitoring have traditionally included the observation of growth characteristics, soil water measurements and water budget type irrigation scheduling. The visual observations will not show incipient stress and both soil moisture and water budget methods are indirect measurements. Ideally a direct measurement of the plant water status should be used for the monitoring process.

Three methods of plant water measurement were compared in this trail utilizing drip irrigated Chenin blanc vines. Leaf water potential was measured with a pressure bomb, transpiration rates with a porometer and a water stress index was determined from measurements of leaf and air temperature. The stress index method and the porometer both produced useable data. The stress index device is much more suitable to commercial use than the more complex, delicate and expensive porometer while still providing data to properly schedule irrigations or monitor stress induction for cultural purposes.

Scheduler™ Plant Stress Monitor
APPLICATION #101
March, 1987

CONTROLLING BUNCH ROT IN CHENIN BLANC GRAPES

The Bunch Rot Problem

Bunch rot diseases may affect the yield and quality of Chenin Blanc wine grapes. In some years, losses in California can be as much as 20%.

Chenin Blanc grapes have tight clusters, a characteristic that makes them even more susceptible to extensive bunch rot infestation. The tighter the cluster, the higher the incidence of cracking caused by the softening and swelling berries. Bunch rot infects the openings at the cracks in the berries' skin and then spreads to the entire cluster.

Recently, an increase in bunch rot disease has been observed by growers, farm advisors, and researchers. The increased use of drip irrigation has been suggested as a possible cause. Drip irrigation applies water more frequently than other methods thereby producing a higher relative humidity under the vines that makes them more susceptible to disease.

Controlling Bunch Rot by Managing Moisture Stress

Research* indicates proper moisture stress management can increase quality and yield by decreasing bunch rot infestations in Chenin Blanc grapes. Berry size and cluster tightness can be manipulated by stressing the vine at precise times and in precise amounts.

Figure 1 shows the growth habits of the grape berry and its response to moisture stress. Table 1 summarizes desirable and undesirable stress for each growth stage of the grape berry.

From the data shown, it can be concluded that planned moisture stress is a viable long-term means for minimizing bunch rot in Chenin Blanc vines without lowering yields.

Planning and Managing Moisture Stress in Chenin Blanc Vineyards

Controlling bunch rot by managing moisture stress is a long-term solution. With that understanding, the following methodology can be used to plan and manage moisture stress in Chenin Blanc vineyards.

In the first year, keep viticulture practices the same but measure moisture stress using the Scheduler. Then, after harvest, plan next year's moisture stress based on a review of actual yields, actual bunch rot losses, Figure 1 and Table 1. Continue measuring stress and making yearly adjustments until yield is maximized and bunch rot losses are minimized.

Methodology for Measuring Moisture Stress in Chenin Blanc Vineyards

Vine moisture stress can be measured directly with the Scheduler Plant Stress Monitor.

Keeping the sun at your back, use the Scheduler to take daily measurements between 11:00 AM and 3:00 PM at various locations throughout the vineyard.

Table 2 relates moisture stress to Scheduler readings.

Table 2

Scheduler Reading	Moisture Stress
<0	No stress
0 to 2	Minimal stress
3 to 4	Moderate stress
4 to 8	High stress
>9	Extreme stress

On rainy or overcast days when less than 450 units of sunshine hit the Scheduler, readings should not be taken. The Scheduler is able to adjust calculations to make up for missed readings.

Print out a hard copy of the results every 2 weeks for use in moisture stress review and analysis after harvest.

* Based on research undertaken by Dr W. Keith Patterson and Dr. Charles F. Krauter Research Scientists, Viticulture Viticulture & Enology Research Center California State University, Fresno.

Table 1

Growth Phase	Growth Characteristics	Desired Moisture Stress
Phase I	Lasts 5 to 7 weeks after full bloom; fruit bud initiation that will determine the size of next year's crop occurs.	Excessive stress may cause fewerclusters the following year. Stress at bloom will result in fewer berries/ cluster. Minimal to moderate stress during Phase I will result in smaller than normal berries and with care, stress can be used to reduce cluster compactness.
Phase II	Lasts 2 to 4 weeks; lag phase, little or no growth occurs. Seeds begin to harden. Sugar accumulation begins. End of Phase II is marked by veraison (onset of color).	Vines stressed from veraison to harvest had lowest amount of bunch rot but fruit also had lower sugar levels and acidity. Vines with moderate stress induced until veraison and then irrigated at 50% Et produced fruit with low rot levels and no negative impact on fruit chemistry.
Phase III	Growth is by cell enlargement. Berries begin to soften. Sugar accumulation proceeds rapidly. Acidity begins to go down.	Stress will result in smaller than normal berries and may delay maturity. Pre-harvest stress has only a minor effect on yield; a slight water shortage just as maturity is approached may hasten ripening.

Source: Winkler, et al. General Viticulture, University of California Press

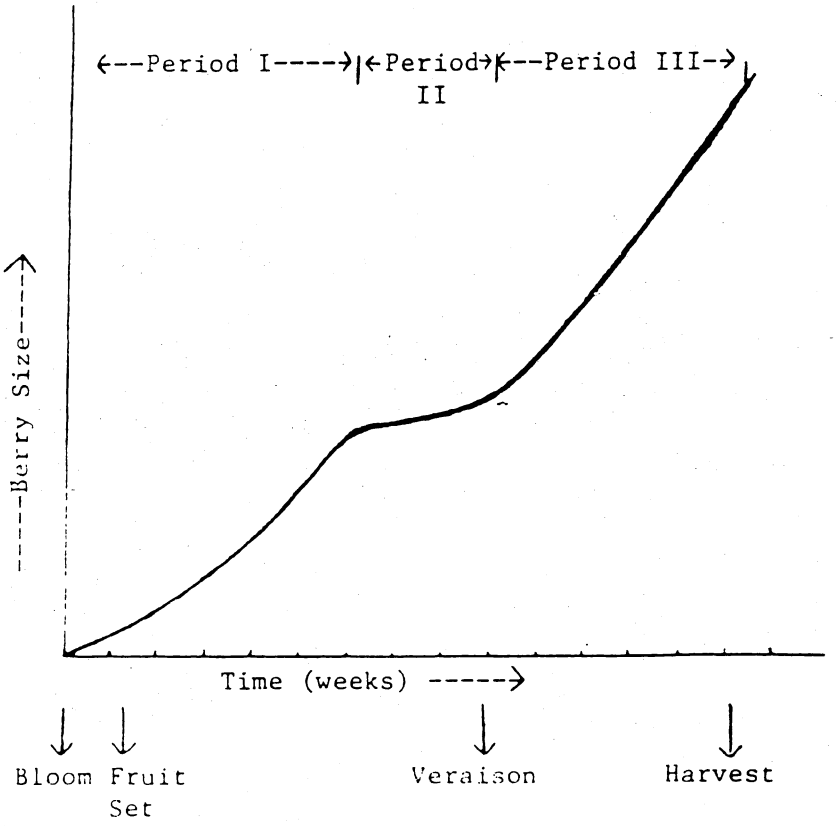
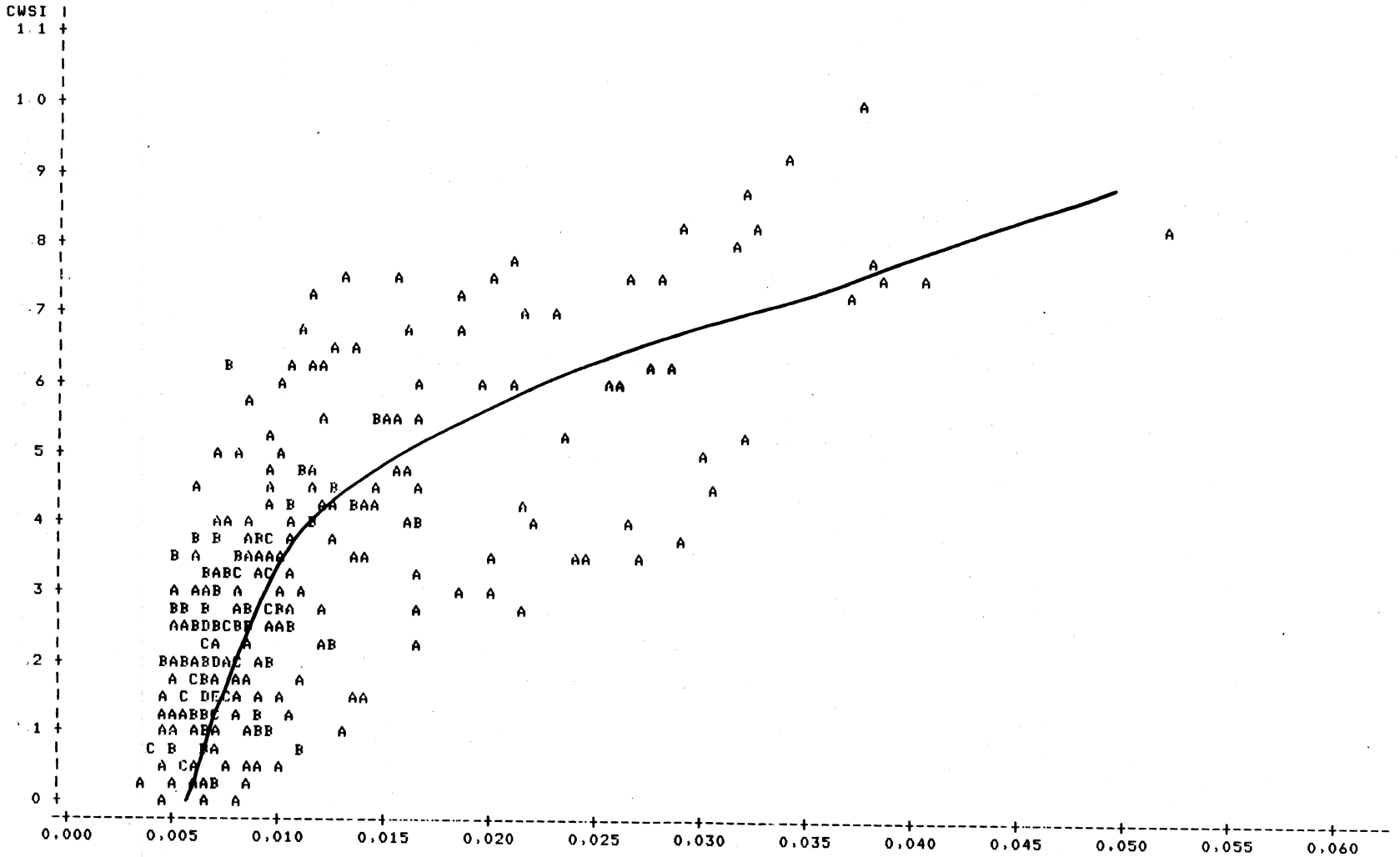


Figure 1. Growth Curve of Grape Berry

RELATIONSHIP BETWEEN CWSI AND STOMATAL RESISTANCE
CHENIN BLANC GRAPES
FRESNO , CALIFORNIA --1986

PLOT OF CWSI*RESIS LEGEND: A = 1 OBS, B = 2 OBS, ETC.



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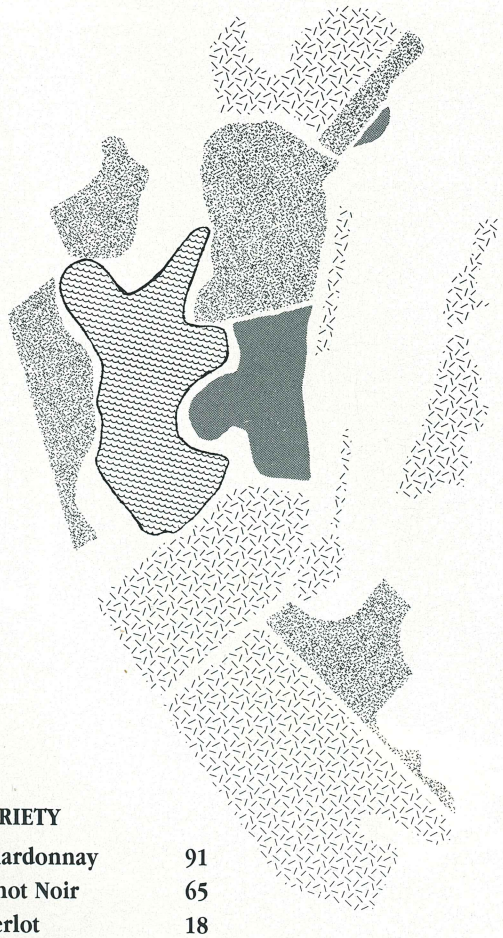
IN-DEPTH COVERAGE FROM VINE TO MARKET ■ January/February 1988

STERLING VINEYARDS

Improving Grape Quality at Winery Lake

Winery Lake acres after conversion



VARIETY	
Chardonnay	91
Pinot Noir	65
Merlot	18
Total Acres	176

Don Neel, Editor

In March, 1986, Sterling Vineyards, Calistoga, CA, purchased the 250-acre Winery Lake Vineyard in the Carneros district. There were 176 acres planted to five different grape cultivars on a variety of soil types and exposures. The Chardonnay and Pinot noir plantings each had more than one clonal selection.

How does a winery/vineyard operation which has managed and developed over 900 acres in Napa Valley approach the task of improving wine grape quality on a 250-acre property planted 20 years ago?

In 1986, Sterling left the vineyard intact and harvested separately as many blocks as possible according to exposure, soil and slope. This allowed the staff to become familiar with the producing vines and the different wines from each location. Sterling's goal was to identify the best possible locations for the Chardonnay, Merlot and Pinot noir grapes to use in its premium table wines.

To improve Winery Lake, 28% of the acreage (50 acres) was T-budded in 1987 to other varieties. The four acres of Gewurztraminer, ten acres of Merlot and 18 acres of Pinot noir vines which were planted in the deepest, richest soils were converted to Chardonnay. Of the 18 acres of hillside Riesling vines, six acres were budded to Chardonnay. The remaining 12 acres were budded to Pinot noir to increase the volume of Pinot noir grapes from hillside vines. The goal was to increase moisture stress in order to produce greater intensity of aroma, flavor and color.

Tucker Catlin, vice-president of vineyard operations, Vince Bonotto, vineyard manager, and Daniel Roberts, vitculturist, began several multi-year experiments in the 1987 growing season to explore how to improve wine grape quality.

Crop-thinning

One three-year experiment with a one-acre hillside Pinot noir planting involves 26% thinning of the crop by cluster removal at berry pause. A 29% reduction in yield was reported by Catlin; the juice analysis has yet to be evaluated.

Another three-year experiment involves 40% thinning, by cluster removal at berry pause, of five acres of heat-treated, large cluster, high-yield, hillside Chardonnay vines.

Stressing Pinot noir Vines

In an attempt to increase color and tannins in Pinot noir, a low phenol variety, a four-acre block of hillside vines was committed to a three-year experiment involving timing and severity of moisture-stress. Sterling hopes that the right combination of these factors will affect phenolics and influence the quantity of grape tannins, as well as the intensity and/or style of aromas and flavors.

This block was divided into eight sub-plots, all of them drip irrigated. Earliest irrigation began on June 6 in four blocks, while four others did not receive any watering until July 2, to induce early stress. Each treatment included irrigation cut-off dates at veraison, 17° Brix, 19° Brix and 22° Brix. The extremes of the experiment were: 73 gallons of water/vine for the season between June 6 and 22° Brix (no stress) and 25 gallons/vine between July 2 and veraison (maximum stress).

No signficant difference in yields was noted, yet variations in berry weight and cluster size were observed. Experimental wine lots were produced from each treatment to evaluate the effects on wine quality.

A new tool to monitor vine stress was used by Roberts. The Scheduler® Plant Stress Monitor, developed by Standard Oil Engineered Materials Company, uses an infrared thermometry-based system to measure the water status of the vines. This tool gives data on vines that gypsum blocks and other soil moisture monitors cannot provide.

Roberts monitored the vines once or twice/week between 11am–4pm in August and September (until harvest) and one more time after harvest. The Scheduler was used to monitor stress before and after watering. Vine stress also was monitored in different soils for future reference to the wine lots made from different soils and irrigation treatments.

He suggests that it is best to measure at the same time each day so that solar radiation is similar. The main advantage of the Scheduler is that it measures the moisture status of the plant instead of the soil (most other types of irrigation monitoring devices–gypsum blocks, tensiometers, and neutron probes–measure the latter). The Scheduler collects data on several factors that influence vine stress, *i.e.*, vine and air temperature, relative humidity and solar radiation.

The infrared information that the Scheduler records allows for monitoring of the following process:

When water is not available to the roots, the leaf stomata close to maintain water pressure within the plant. This cuts off the evaporative cooling which occurs when vines are well-watered. The result is stressed vines that have a warmer leaf surface than well-irrigated vines. Although infrared measurements are not new to agriculture, the Scheduler's built-in computer permits the averaging of a large number of samples to give much more accurate information.

Trellis Experiments

In 1988, a trellis experiment will be implemented to facilitate integrated pest management in a high-vigor Chardonnay block. The goal is to deliver more ultraviolet light to the fruit, which reduces mildew potential and delivers more heat and light to dry up the moisture which can cause rot.

Daniel Roberts using Scheduler at Winery Lake Vineyard.

There is a wine quality goal as well. Under heavy shade, Chardonnay fruit tends to have a green color instead of the ideal golden, translucent color of fruit on stressed, hillside vines. A reduction in malic acid and lower pH are expected.

This experiment includes six rows with 100 vines each of Geneva Double Curtain (GDC) and Lyre trellis (both with divided canopies) inter-mixed with the 3-wire, 24-inch 'T' trellis now employed. The trellis frameworks will be installed by A & P Ag Structures before bud break.

Quadrilateral cordons will be positioned on the 48-inch wide GDC trellis, and the shoots will be held down by two shoot positioning wires. The Lyre trellis will have cordons 48-inches apart, with two movable catch wires on each side of the trellis holding the shoots upright.

In 1989, six new scattered hillside acres will be planted to Pinot noir. A 1.5-acre parcel will contain 6–8 clonal selections on the same rootstock. Another block will contain one clonal selection and several rootstocks for comparison.

Conclusion

When asked why they are putting so much effort into modifying Winery Lake Vineyard, Catlin responded: "Answering questions about the ideal combination of variety, climate, soil, rootstock, clones and trellises can take ten years to be conclusive.

"In ten years, a lot of the vineyards planted in the 1960's and early 1970's will be ready for replanting. Hopefully the questions we're asking in these vineyards now will give us site-specific answers that we can adopt for the next generation of vineyards at Winery Lake and elsewhere."

A lot of energy is being devoted to improving winegrape quality at Winery Lake Vineyard. We look forward to publishing the acheivements when the results are in.

Reprinted from the January/February 1988 issue.

PRACTICAL WINERY & VINEYARD

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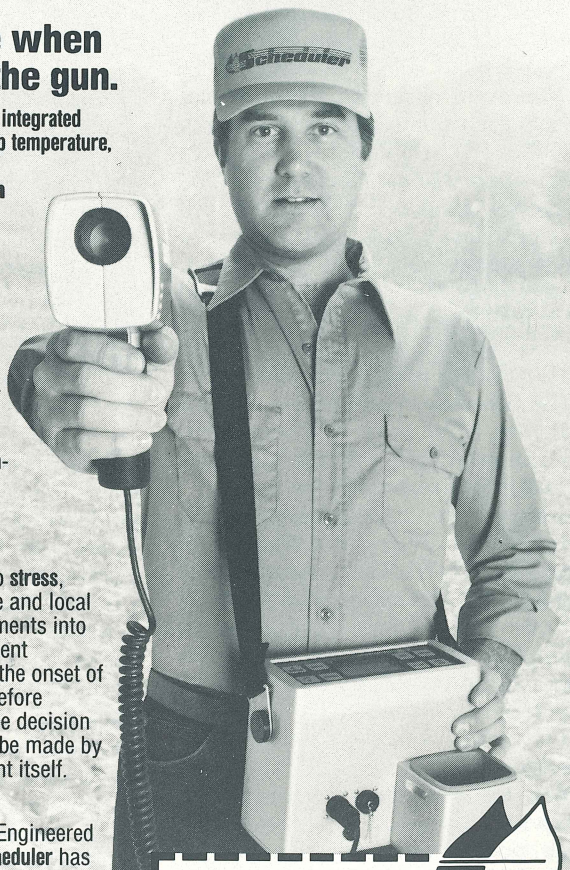
CROP TALK

Plants don't lie when they're under the gun.

The Scheduler,® a portable, integrated sensor package, measures crop temperature, air temperature, relative humidity and solar radiation in your field for direct and instant plant feedback.

You've read about the **Scheduler** Plant Stress Monitor, maybe seen it at an ag show. With it, growers time irrigations to critical crop growth changes — and reduce **unnecessary** irrigations, saving water, energy and labor costs without loss of yield.



Advanced crop management tool

It works by monitoring crop **stress**, translating leaf temperature and local field environment measurements into on-the-spot plant management information. (It can predict the onset of yield-robbing stress days before there's visible evidence.) The decision to irrigate or wait can now be made by a direct signal from the plant itself.

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Scheduler charts plant stress

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The Leading EDGE

Irrigation has traditionally been scheduled according to factors that do not include plant measurements. Since the early 1970s, the USDA, as well as several universities have been developing a crop water stress index (CWSI). This index is based on the principle that a surface which is evaporating water is cooler (under the same ambient conditions) than a similar non-evaporating surface. Hence, the rate of water evaporation from a leaf surface modifies plant temperatures. Thus, it is possible to define an index which directly responds to the transpiration rate of a leaf. This index also serves as an indicator of plant stress status.

The Stress Index

The stress index in the Schedule® is:

$$\text{Index} = 10^{*}\frac{(TC - TA - Min)}{Max - Min} = 1 - \frac{ET}{ET_p} \quad \text{Eq. (1)}$$

ET is the actual transpiration rate. ET_p is the potential transpiration rate. Min is the minimum temperature a rapidly transpiring plant can achieve under a given set of environmental conditions. Max is the temperature a maximally stressed plant can achieve under a given set of environmental conditions.

Max and min are computed from proprietary algorithms. The theoretical range of the index is 0-10 for a given crop. In actual practice in the field, observed values range between -3 and $+13$.

To compute the index, it is best to simultaneously measure four parameters: canopy temperature, ambient air temperature, relative humidity and solar radiation.

The *Scheduler* can measure each parameter 4 times per second. Up to 55 samples can be collected per data "burst". A burst of 55 samples requires 12-15 seconds to collect the data, with an additional 2-3 minutes calculating time. Up to 18 "bursts" can be included in a set of field averages.

Several software options are available (Table 1).

Scheduler Research

The technology on which the Scheduler is based began as far back as 1842. Since that time, the ability of researchers to measure plant temperatures has progressed from cumbersome thermocouple systems requiring ice baths to battery powered hand-held infrared thermometers. A large volume of information now exists which shows that moisture stress causes elevated plant temperatures relative to healthy plants.

TABLE 1. Scheduler Software Features

General

- Easy to use. Only eight buttons to push (ON/OFF, HELP, PRINT, DEL, ENTER, UP, CALC, DOWN). No computer experience needed.
- Seven pre-programmed crops per unit.
- RS-232 compatible for down-loading to external computers and printers.
- Easily replaced EPROM's for changing between software programs. (Currently this change is made for the user only by our technicians).
- Modem communication for easily changing crops and their associated baselines.
- Real-time clock.
- Battery test features.
- Visual display of the difference between crop and air temperatures.
- Sunlight level feature to automatically delete any data collected at less than 65% full sunlight. The user can enable or disable this feature at will.

Production Software

- 15-day data storage for stress index values for each of 30 separate fields or locations.
- Graphical display of the stress index trends for the most recent 15 days for each of 30 fields. This allows rapid in-field decisions without using an external computer.
- One-day storage of mean values of crop, temperature, air temperature, relative humidity, solar radiation and the stress index. Also stores the time, date and number of samples associated with each average. Means are automatically deleted at midnight.

R&D Software Features

- One day data storage for average values of crop temperature, air temperature, relative humidity, solar radiation and the stress index for 240 separate fields. Standard deviation of crop temperature, vapor pressure deficit, date, time, field number, crop name, and number of samples collected with each average. No data is deleted automatically.
- Ability to transmit all data in real-time to an external RS-232 device, making it possible to capture all the data observed by the Scheduler®.

Additional software applications programs are being developed.

Since the early 1970s, the USDA has been developing procedures which quantify the systematic relationship of leaf temperatures to environmental parameters such as relative humidity, air temperature and solar radiation. Many different universities have joined in that effort.

In 1984, Standard Oil began developing a commercial version of this technology. Nationwide testing was conducted on corn in 1985 using a prototype model. This test showed that the technology could be made in a form acceptable to growers and that the cost/benefit ratio could justify its purchase.

A second model was built in 1986 which incorporated the lessons of 1985. These models were made commercially available and were also installed on a number of research projects. Although many crops had been researched by others using stress index theory, the decision was made to validate existing baselines and develop new baselines for crops that had not been researched. This effort resulted in an extensive data base and the discovery of calculation procedures which enhanced the stability of the index in cool and humid regions. Research is continuing on improved calculation procedures.

The lessons of 1984-1986 were incorporated into the 1987 model, resulting in a technically accurate, easy-to-use instrument which provides a great deal of information about plant stress status.

How to Interpret the Stress Index

Several interpretive techniques are being used with the *Scheduler* stress index:

Technique 1 – Threshold Values: With this technique, a user measures the stress index of a crop with the *Scheduler* whenever it is convenient. If the index exceeds a threshold value (usually some constant value the user determines), then the user concludes that stress has begun. As long as a crop canopy stays relatively unchanged between irrigation cycles and the crop does not undergo any radical physiological change, such as rapid leaf expansion, this approach works well. This approach requires some modification if used during a period of rapid crop development, since the relative influence of soil (ground cover) and crop structure on indicated temperatures may change the normal index reading. For example, higher index readings on young healthy cotton than on a mature healthy cotton would be normal.

Technique 2 – Relative Values: With this technique, a user does not consider the past behavior of the index or its absolute value. He is interested in relative differences between areas. As long as a user has an area which he can use as a healthy reference with a high degree of confidence, this approach is very satisfactory. Index differences of 2-3 between an area and a healthy reference area usually indicate the need for irrigation. This approach works well on large operations where is is generally easy to find a recently-irrigated area.

Technique 3 – Seasonal Trends: This technique presumes that a user has a data

Photo by Wines & Vines

Bronson Gardner with the Scheduler at a Fresno news conference.

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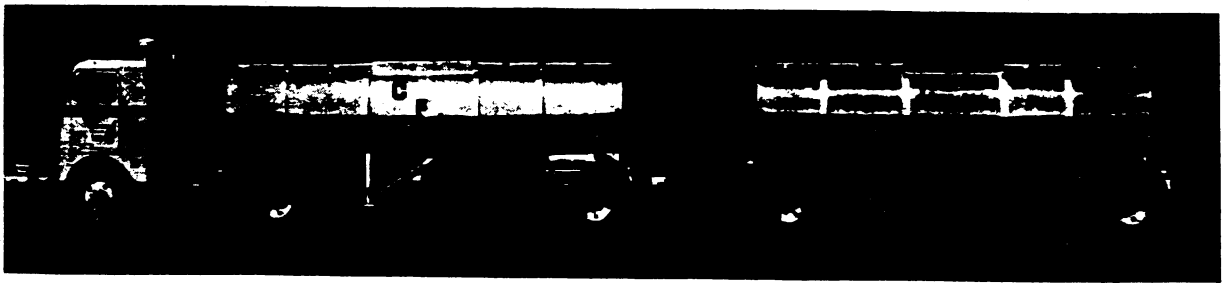

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TABLE 2. Scheduler Hardware Features

- Aspirated air temperature and humidity sensors.
- Infrared thermometer
  Distance: one inch to infinity
  Range: ±60°C from ambient
  Field of view: 6°
  Spectral response: 8-14 um
  Accuracy: ±0.5°C
  Repeatability: ±0.1°C
  Emissivity: 0.99
  Operating distance: 1 inch to infinity
- Ambient temperature
  Range: 0°C to 60°C
  Accuracy: ±0.5°C
  Resolution: 0.1°C
- Humidity
  Range: 0 to 100%
  Accuracy: ±5%
- Solar Radiation:
  Range: 0 to 100 mW/cM^2
  Accuracy: ±10%
- Response Time:
  Screen update <2.0 seconds
  Sample frequency <0.5 seconds
- Microprocessor: 64-K — 8 bit.
- Display: 2½ × 1½ LCD on processor
  1½ × 1 inch on sensor gun
- Serial Interface:
  RS-232 25 pin male connection
  Band Rates: 50-2400 (selectable)
  Character sizes: 5-8 (selectable)
  other download parameters also selectable
- Softside carry case
- Warranty: 1 year
- Power — 6 C cell batteries, with an expected life of 20 operating hours
- Recharging port provided for use with rechargeable batteries

base for his crop. By examining seasonal graphs of the normal index readings for his crop as a function of crop growth stage, a user can determine if the index readings he is obtaining are within or outside the range of normally expected values. This approach allows for the tailoring of crop stress management to suit specific agronomic objectives such as increasing sugar in grapes.

Technique 4 — Cumulative Index Values: Another approach is to take *Scheduler* readings on a systematic basis, such as daily, every second day, etc. When data is collected in this manner, it is possible to begin summing the stress index readings. This approach is similar to the growing degree-day approach, except that plant stress readings are substituted for air temperature readings.

TABLE 3. Selected Institutions Where Scheduler Research Was Conducted in 1986 and The Results Obtained.

Institution	Crop	Data Obtained Showing the Scheduler Indices are Related to:
Texas A&M	Turf	Water use, plant health
Univ. of Nebraska	Corn, Wheat Soybeans	Baseline confirmation
Oregon State Univ.	Potatoes	Water use, soil water, yield quality
Fresno State Univ.	Grapes	Water use, stomatal resistance, yield quality, disease
USDA, Arizona	Alfalfa	Water use, yields
Univ. of Calif.	Cotton	Leaf water potential, yields

In addition, we obtained data from independent researchers and the USDA on the following crops: pecans, jojoba, nectarines, almonds, tomatoes, cucumbers, celery, wheat, sugar beets, and several others. Extensive research is also being conducted in 1988 on several crops.

Studies have shown that cumulative values are strongly related to the total amount of water used. This makes it possible to schedule irrigations on crops where any stress must be avoided, but where over-irrigation must also be avoided, such as celery.

In addition to cumulative stress index values, it is also possible to cumulate VPD (vapor pressure deficit) values. Cumulative VPD values are a measure of how much drying power a crop has been exposed to, serving as an indicator of disease possibilities. VPD values for cumulative purposes can be collected whenever the user feels it is most appropriate. Currently, the calibration of all cumulative values is conducted by the user.

(Gardner is product technical manager, Standard Oil Engineered Materials Co., Solon, Ohio. His remarks were presented at October's Vineyard and Water Management Seminar at CSU/Fresno. The Scheduler costs approximately $4,300, with software available for another $400.)

TABLE 4. Applications for The Scheduler Plant Stress Monitor

The Scheduler provides data for a wide range of research applications.

- Scheduling irrigation in many crops.
- Scheduling STAM applications in rice.
- Controlling bunch-rot in grapes.
- Scheduling Round-up applications on weeds (the higher the stress, the lower the kill rate).
- Locating "hot spots" caused by disease, insects, compaction, plugged irrigation emitters, etc.
- Estimating daily evapotranspiration values.
- Measuring fruit temperatures in grapes and other crops.
- Measuring the temperature of vital plant parts, such as stem temperatures in grapes.
- Controlling humidity levels in vineyards.
- Generally reducing the amounts of over-irrigation.
- Quantifying the effect of chemical applications on plants. Herbicides, insecticides and fungicides affect plants to varying degrees.
- Quantifying the drying power of the air, to relate to disease factors.
- Estimating yield reductions due to stress.
- Controlling plant responses and fruit quality by careful management of stress levels.

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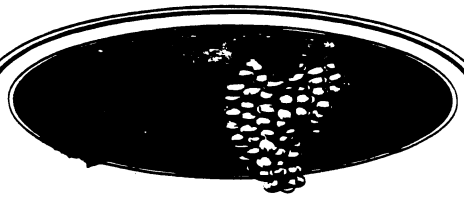

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HOW THE SCHEDULER MONITOR DETECTS CROP STRESS

Irrigation has traditionally been scheduled according to factors that are lacking direct crop measurements. However, research scientists from Standard Oil Engineered Materials Co. determined that irrigation scheduling could be more efficient when the crop tells growers when to water. Leaders from the irrigation industry agreed and encouraged these R & D scientists to pursue this effort.

Starting with this concept, the scientists developed the *Scheduler*™ plant stress monitor, a sophisticated but easy-to-use tool that allows maximum efficiency in scheduling irrigation.

The *Scheduler* is the first portable unit of its kind for determining crop stress. A computer calculates plant stress from inputs provided by an infrared thermometer and sensors for air temperature, relative humidity and sunlight intensity. Plant stress is detected 3-5 days before crop yield is adversely affected.

"The accuracy of the *Scheduler* has been proven by years of field testing and use at more than 30 sites across the nation," said Standard's Dr. Bronson Gardner, one of the product's developers and scientist in charge of field trials.

"The *Scheduler* detects a plant that is not transpiring at an optimum rate, this plant is under stress," Gardner explained. "A majority of the time, it is simply stress due to the lack of water, which indicates the need for irrigation, but there are times when the plant will undergo stress due to over-irrigation, disease, insect damage and nutritional deficiencies.

Wines & Vines Photo

Prof. Charles Krauter demonstrated the Scheduler.

"If there is sufficient available soil moisture, and the plant continues being stressed after an initial reaction to being watered, then you know there is another problem. In this instance the *Scheduler* is being used as a diagnostic tool," he said.

As carbon-dioxide enters a leaf and water evaporates from the leaf, the plant is transpiring. The small pores on the surface of leaves (stomata) regulate this transpiration by opening and closing. The stomates constrict or completely close when the plant is under stress and this slows or stops transpiration.

As transpiration slows, the leaf temperature rises (relative to the surrounding environment). The *Scheduler* plant stress monitor measures those minute changes in leaf temperature and interprets them as the stress index.

Although the *Scheduler* is an extremely compact unit powered by a rechargeable battery, the unit contains a powerful yet simple computer program to calculate the crop stress, provide a readout and store information. A graphic readout shows the pattern of plant stress as it develops. Data for up to 30 individual fields during a 15-day period can be retained in the unit's memory. By linking to an external computer/printer, a permanent record can be retained or a data base established.

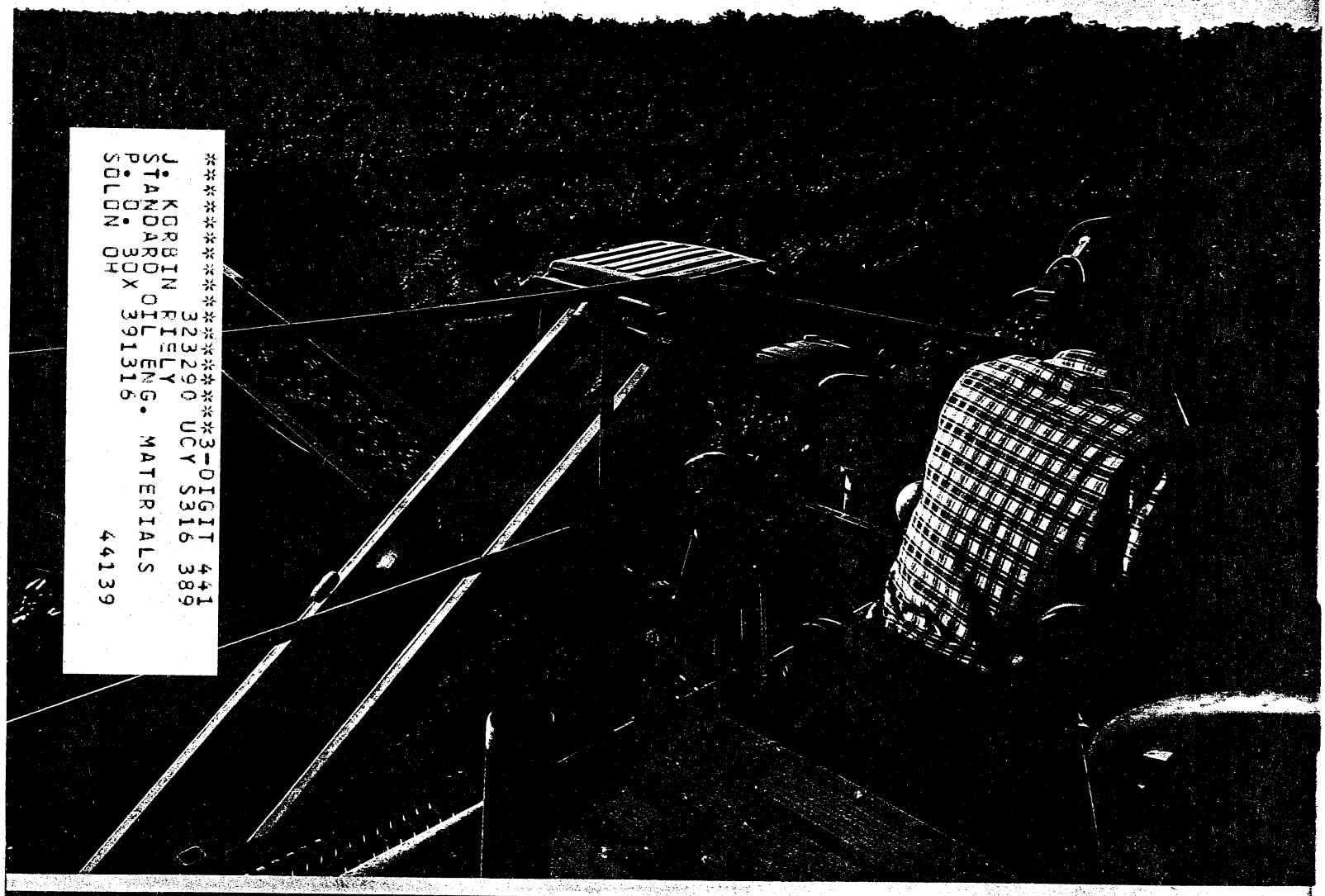
The device is programmable for numerous crops. Stress indexes are developed for each crop because different plant species relate to the environment differently. "For each crop we have to know the "base-line" or normal reading for a non-stressed crop," Gardner explained. "Departures from that base-line indicate some type of stress. Once the plant stress has increased to a predetermined level, irrigation needs to begin.

"Depending upon the crop," he added, "growers may want to provide a certain amount of stress at specific growth phases, or provide extra irrigation at points critical to crop yield. The bottom line is that the *Scheduler* gives growers flexibility in managing their crops never before available."

October 1988 • $2.00
California and Western States

Grape Grower

Mixing Old, New On Road To Success



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Infrared Gun Proving To Be Good Irrigation Tool

Growers Attack Vintners' Fund-Raising Tactics

California and Western States
Grape Grower

October 1988
Vol. 19 • No. 10

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California and Western States GRAPE GROWER (ISSN 092-2145) published monthly by Western Agricultural Publishing Co., Inc., also publishers of *California-Arizona Cotton, Nut Grower,* and *Agribusiness Fieldman,* 4974 E. Clinton Way, Suite 123, Fresno, CA 93727-1558, (209) 252-7000. ☐ Second class postage paid at Fresno, Calif. and additional mailing offices. ☐ POSTMASTER: please send address changes to GRAPE GROWER, 4974 E. Clinton Way, Suite 123, Fresno, CA 93727-1558. ☐ Copyright 1988. ☐ Cover and entire contents are fully protected by copyright and must not be reproduced in any manner whatsoever without written permission.

Our Cover: Stanislaus County, Calif. grape grower Mike Berryhill pilots a mechanical grape harvester through his Zinfandel vineyard near Ceres.
Photo By Kevin Hall, Assistant Editor

Page 9

The infrared gun is becoming an increasingly popular way to measure plant stress for irrigation management. California State University, Fresno researchers are working to determine what the ideal temperature should be when the plant is not stressed, and they are finding that number to differ significantly between grape varieties.

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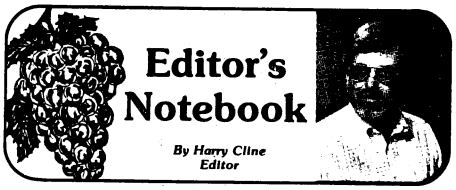
U.S. Sen. Pete Wilson believes agriculture did not get the best deal it could in immigration reform and he stands ready to battle once again for farmers in the U.S. Senate.



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There have been revolutions over the issue of taxation without representation and a group of California grape growers are saying that's the case once again with wineries trying to raise grower funds for viticultural research.

Also Featured In This Issue:

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22 Product Information

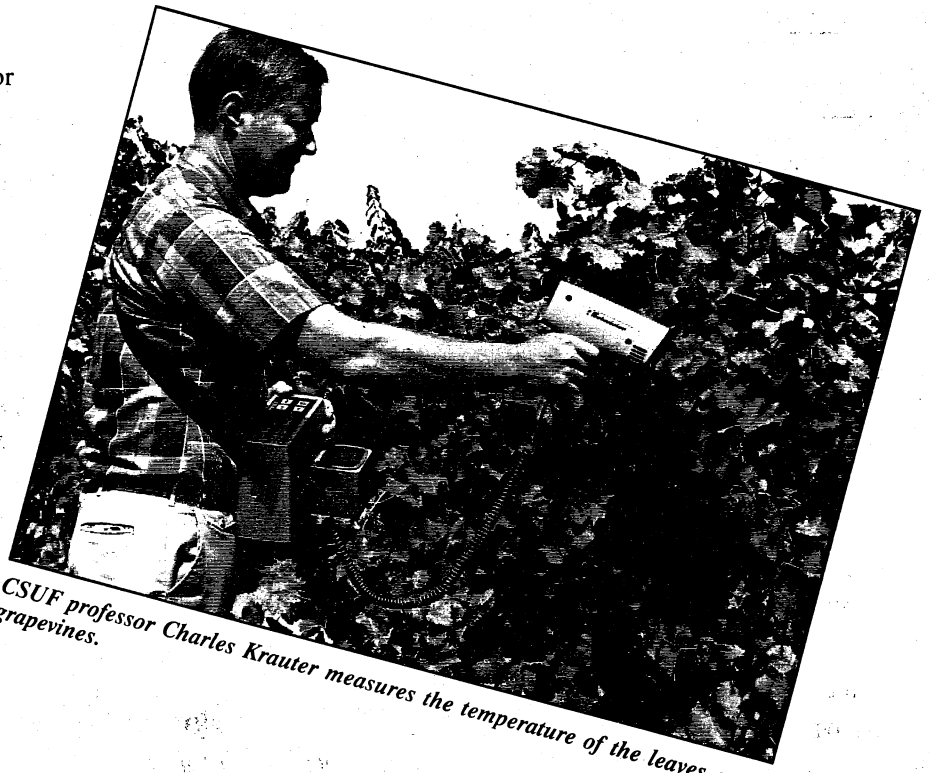
CSUF Testing Mobile, Stationary Infrared Guns

By Linda Renn
Special Correspondent

The infrared plant stress monitor is one of the newest irrigation weapons available to farmers. It determines stress by measuring the temperature of plant foliage. According to Charles F. Krauter, professor of irrigation science at California State University, Fresno, the infrared plant stress monitor has several advantages over other irrigation scheduling tools.

"The big advantage of this is the combination of speed and accuracy," he said. "One person can collect as much information as 10 people using tensiometers or neutron probes. With this, a grower can tell whether the plants are stressed in a matter of minutes."

CSUF's Center for Irrigation Technology (CIT) has been doing research for the past three years on the "Scheduler," an infrared plant stress monitor developed by the Engineered Materials Division of Standard Oil of Ohio. Krauter said Everest Instruments makes a similar device.



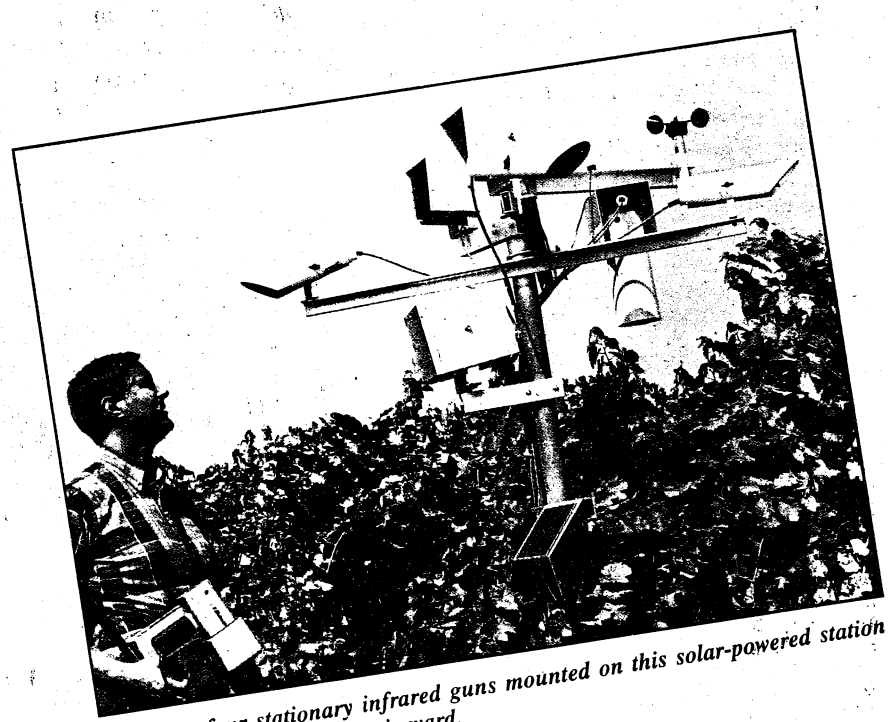
CSUF professor Charles Krauter measures the temperature of the leaves on grapevines.

Space-Age Gun

The device actually looks much like a space-age gun. It is easily operated by one person. The accompanying pack, which is basically an IBM PC, is carried by an over-the-shoulder strap. By pointing the infrared gun at the foliage, one person can take a single reading from one leaf or scan 50 different parts of a vineyard and obtain an average of the 50 readings. Ideally, the Scheduler should be used at midday and should be targeted at sunlit leaves. It can store data from 200 different fields, and its computer can be hooked up to a printer.

A tiny fan in the gun sucks in air, allowing the Scheduler to measure both temperature and humidity. The infrared sensor measures the temperature of the leaf at which it is aimed. The gun works under the theory that a leaf without stress will cool itself through evaporation and will have a lower temperature than the

Continued on page 11



There are four stationary infrared guns mounted on this solar-powered station middle of a Chenin Blanc vineyard.

CSUF Testing Mobile

Continued from page 9

air around it.

The three inputs—air, humidity and leaf temperature—are assimilated by the Scheduler in seconds to give a stress index number ranging from zero to 10 with zero denoting no stress. Krauter said a grower can be reasonably sure the vines are not stressed when a reading is below three.

Standard Oil has been funding the CIT's research on the infrared gun. The center has been working to pinpoint just what the desired leaf temperature should be when the plant is not stressed. Krauter noted that the stress index can differ not only from crop to crop but from one grape variety to another.

The tool sells for $4,000 to $4,200 and this past year went into full-scale production.

A stationary version of the Scheduler is also being researched by the center. It currently perches just above vine level in a Chenin Blanc vineyard on the CSUF campus, looking much like a mini-weather station.

Four infrared sensors pointing in as many different directions take readings from the surrounding vines. Leaf temperature readings, plus air temperature, humidity and current wind conditions, are fed to a computer several hundred feet away via an infrared system that works much like a television remote control. New readings are transmitted every three and a half minutes.

But even with high-tech aids, the bottom line is that the grower still has to make the final decision as to when and how much to irrigate.

"At this point and probably for quite some time," he noted, "it will still be up to the grower to decide what number to use to schedule his next irrigation." For example, early in the season a grape grower may not want his vines stressed, but nearer harvesttime raisin growers or wine grape growers may want to deliberately hold off on watering.

CSUF Grape Day Set For Nov. 5

A series of presentations, field demonstrations and equipment displays will highlight Grape Day, Nov. 5, at California State University, Fresno.

The event will be held at the university's Viticulture and Enology Research Center (VERC) located on Barstow Avenue between Cedar and Maple. Registration will begin at 8 a.m., with the program scheduled from 9 a.m. to noon, followed by lunch. Vendors will display equipment and other products from 9 a.m. to 2 p.m.

Sessions will include topics such as in-arch grafting, sulfur dioxide residues, bunch rot ethanol emission control devices and raisin processing innovations.

For more information, call (209) 294-2361.

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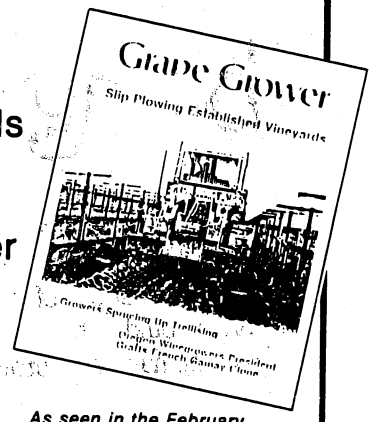

As seen in the February 1988 Grape Grower

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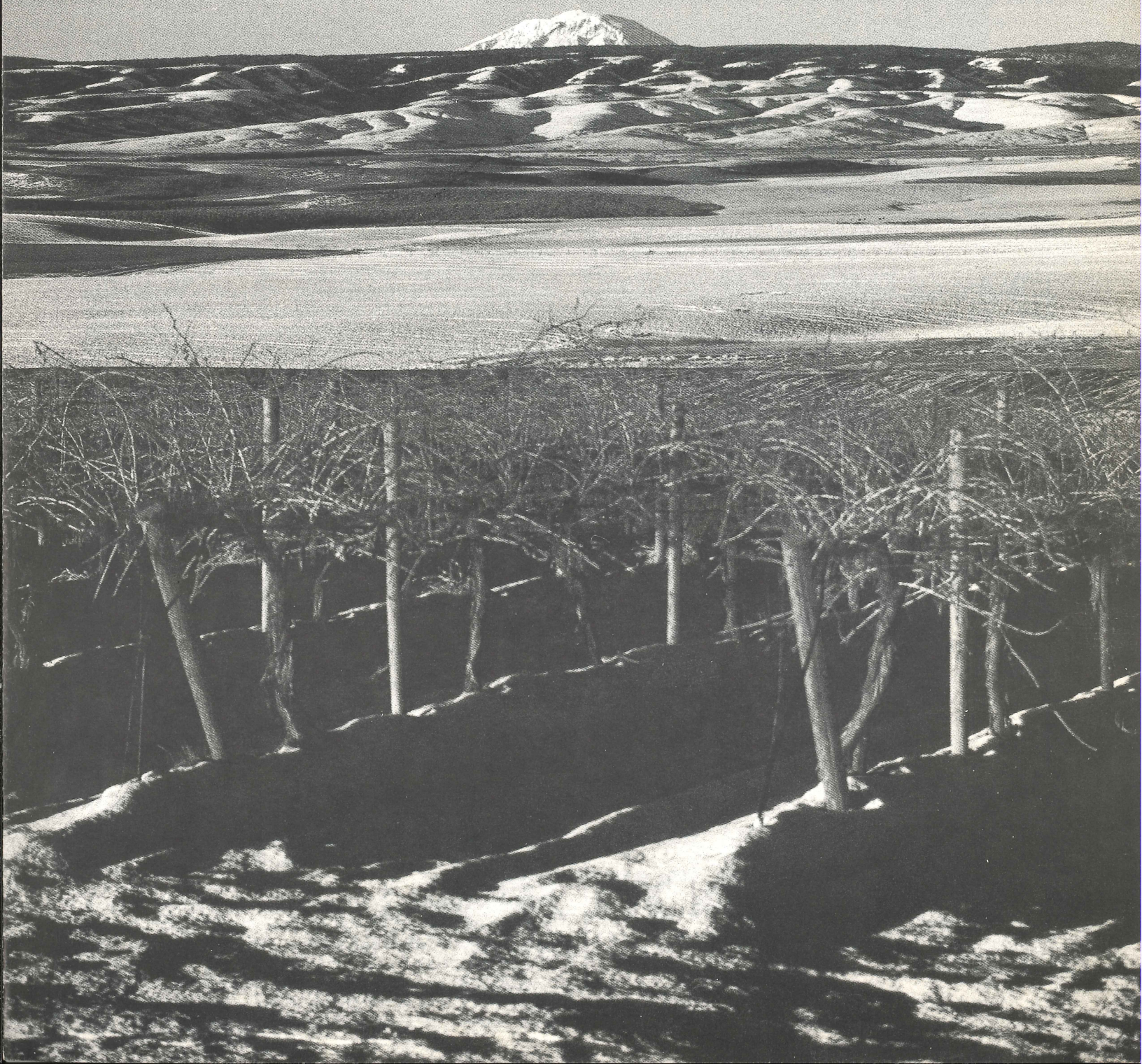
PRACTICAL WINERY & VINEYARD

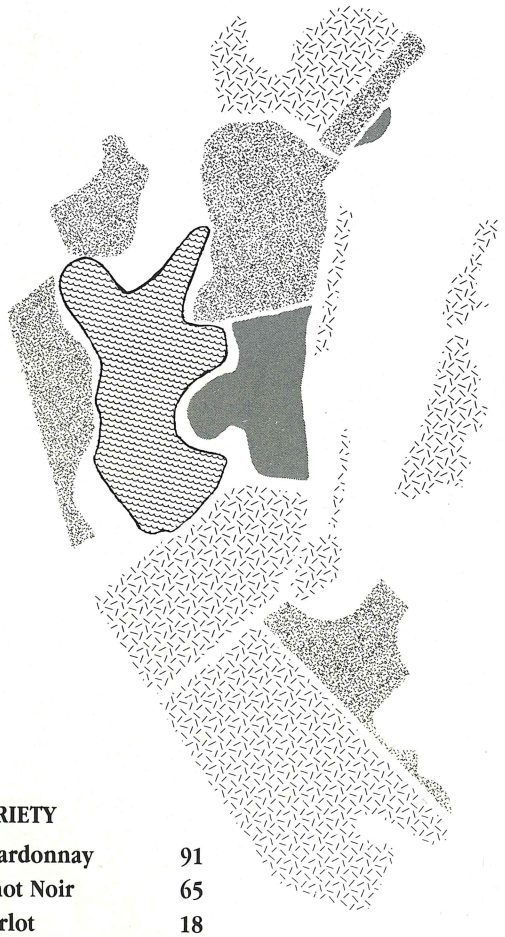
IN-DEPTH COVERAGE FROM VINE TO MARKET ■ January/February 1988



STERLING VINEYARDS

Improving Grape Quality at Winery Lake

Winery Lake acres after conversion



VARIETY	
Chardonnay	91
Pinot Noir	65
Merlot	18
Total Acres	176

Don Neel, Editor

In March, 1986, Sterling Vineyards, Calistoga, CA, purchased the 250-acre Winery Lake Vineyard in the Carneros district. There were 176 acres planted to five different grape cultivars on a variety of soil types and exposures. The Chardonnay and Pinot noir plantings each had more than one clonal selection.

How does a winery/vineyard operation which has managed and developed over 900 acres in Napa Valley approach the task of improving wine grape quality on a 250-acre property planted 20 years ago?

In 1986, Sterling left the vineyard intact and harvested separately as many blocks as possible according to exposure, soil and slope. This allowed the staff to become familiar with the producing vines and the different wines from each location. Sterling's goal was to identify the best possible locations for the Chardonnay, Merlot and Pinot noir grapes to use in its premium table wines.

To improve Winery Lake, 28% of the acreage (50 acres) was T-budded in 1987 to other varieties. The four acres of Gewurztraminer, ten acres of Merlot and 18 acres of Pinot noir vines which were planted in the deepest, richest soils were converted to Chardonnay. Of the 18 acres of hillside Riesling vines, six acres were budded to Chardonnay. The remaining 12 acres were budded to Pinot noir to increase the volume of Pinot noir grapes from hillside vines. The goal was to increase moisture stress in order to produce greater intensity of aroma, flavor and color.

Tucker Catlin, vice-president of vineyard operations, Vince Bonotto, vineyard manager, and Daniel Roberts, vitculturist, began several multi-year experiments in the 1987 growing season to explore how to improve wine grape quality.

Crop-thinning

One three-year experiment with a one-acre hillside Pinot noir planting involves 26% thinning of the crop by cluster removal at berry pause. A 29% reduction in yield was reported by Catlin; the juice analysis has yet to be evaluated.

Another three-year experiment involves 40% thinning, by cluster removal at berry pause, of five acres of heat-treated, large cluster, high-yield, hillside Chardonnay vines.

Stressing Pinot noir Vines

In an attempt to increase color and tannins in Pinot noir, a low phenol variety, a four-acre block of hillside vines was committed to a three-year experiment involving timing and severity of moisture-stress. Sterling hopes that the right combination of these factors will affect phenolics and influence the quantity of grape tannins, as well as the intensity and/or style of aromas and flavors.

This block was divided into eight sub-plots, all of them drip irrigated. Earliest irrigation began on June 6 in four blocks, while four others did not receive any watering until July 2, to induce early stress. Each treatment included irrigation cut-off dates at veraison, 17° Brix, 19° Brix and 22° Brix. The extremes of the experiment were: 73 gallons of water/vine for the season between June 6 and 22° Brix (no stress) and 25 gallons/vine between July 2 and veraison (maximum stress).

No signficant difference in yields was noted, yet variations in berry weight and cluster size were observed. Experimental wine lots were produced from each treatment to evaluate the effects on wine quality.

A new tool to monitor vine stress was used by Roberts. The Scheduler® Plant Stress Monitor, developed by Standard Oil Engineered Materials Company, uses an infrared thermometry-based system to measure the water status of the vines. This tool gives data on vines that gypsum blocks and other soil moisture monitors cannot provide.

Roberts monitored the vines once or twice/week between 11am–4pm in August and September (until harvest) and one more time after harvest. The Scheduler was used to monitor stress before and after watering. Vine stress also was monitored in different soils for future reference to the wine lots made from different soils and irrigation treatments.

He suggests that it is best to measure at the same time each day so that solar radiation is similar. The main advantage of the Scheduler is that it measures the moisture status of the plant instead of the soil (most other types of irrigation monitoring devices–gypsum blocks, tensiometers, and neutron probes–measure the latter). The Scheduler collects data on several factors that influence vine stress, *i.e.*, vine and air temperature, relative humidity and solar radiation.

The infrared information that the Scheduler records allows for monitoring of the following process:

When water is not available to the roots, the leaf stomata close to maintain water pressure within the plant. This cuts off the evaporative cooling which occurs when vines are well-watered. The result is stressed vines that have a warmer leaf surface than well-irrigated vines. Although infrared measurements are not new to agriculture, the Scheduler's built-in computer permits the averaging of a large number of samples to give much more accurate information.

Trellis Experiments

In 1988, a trellis experiment will be implemented to facilitate integrated pest management in a high-vigor Chardonnay block. The goal is to deliver more ultraviolet light to the fruit, which reduces mildew potential and delivers more heat and light to dry up the moisture which can cause rot.

Daniel Roberts using Scheduler at Winery Lake Vineyard.

There is a wine quality goal as well. Under heavy shade, Chardonnay fruit tends to have a green color instead of the ideal golden, translucent color of fruit on stressed, hillside vines. A reduction in malic acid and lower pH are expected.

This experiment includes six rows with 100 vines each of Geneva Double Curtain (GDC) and Lyre trellis (both with divided canopies) inter-mixed with the 3-wire, 24-inch 'T' trellis now employed. The trellis frameworks will be installed by A & P Ag Structures before bud break.

Quadrilateral cordons will be positioned on the 48-inch wide GDC trellis, and the shoots will be held down by two shoot positioning wires. The Lyre trellis will have cordons 48-inches apart, with two movable catch wires on each side of the trellis holding the shoots upright.

In 1989, six new scattered hillside acres will be planted to Pinot noir. A 1.5-acre parcel will contain 6–8 clonal selections on the same rootstock. Another block will contain one clonal selection and several rootstocks for comparison.

Conclusion

When asked why they are putting so much effort into modifying Winery Lake Vineyard, Catlin responded: "Answering questions about the ideal combination of variety, climate, soil, rootstock, clones and trellises can take ten years to be conclusive.

"In ten years, a lot of the vineyards planted in the 1960's and early 1970's will be ready for replanting. Hopefully the questions we're asking in these vineyards now will give us site-specific answers that we can adopt for the next generation of vineyards at Winery Lake and elsewhere."

A lot of energy is being devoted to improving winegrape quality at Winery Lake Vineyard. We look forward to publishing the acheivements when the results are in.

Reprinted from the January/February 1988 issue.

PRACTICAL WINERY & VINEYARD

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CROP TALK

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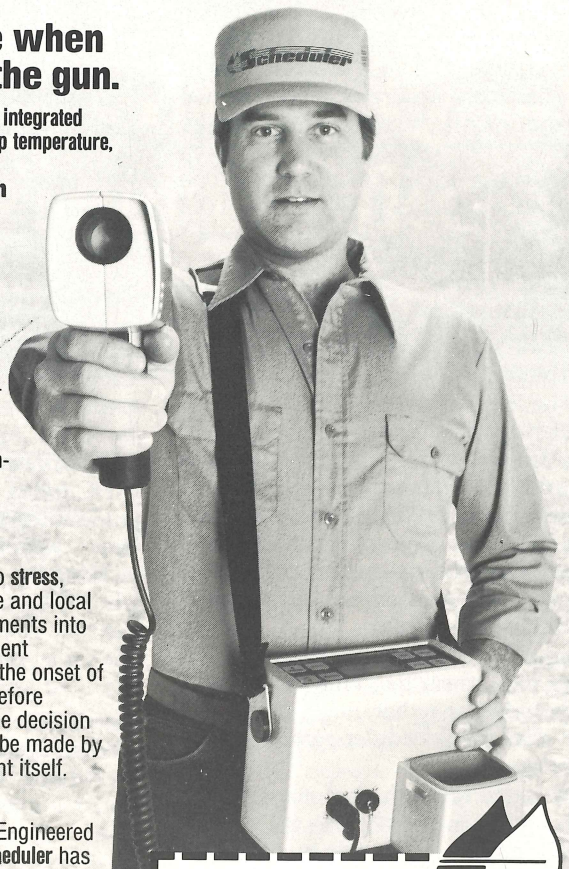

Advanced crop management tool

It works by monitoring crop **stress**, translating leaf temperature and local field environment measurements into on-the-spot plant management information. (It can predict the onset of yield-robbing stress days before there's visible evidence.) The decision to irrigate or wait can now be made by a direct signal from the plant itself.

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OCTOBER 1989

Update

CSU • FRESNO CALIFORNIA AGRICULTURAL TECHNOLOGY INSTITUTE

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Enologist seeks new essence in wine

The first bins of grapes carted from campus vineyards to CSU, Fresno's research winery last month received no unusual treatment before being run through the crusher. But the wine produced from those grapes *will* get some special treatment. And the quality of its flavor, as determined by selected samplers next spring, could have far reaching effects on the profitability of the commercial wine industry in California.

In a first-time experiment at CSU, Fresno and for the wine industry, enology researchers at the Viticulture and Enology Research Center (VERC) will capture ethanol and other volatiles emanating from tanks of fermenting grape juice and later inject them back into the wine. The idea of such a process isn't new. But the cost of implementing it on a commercial scale has been enough to keep winemakers from pursuing it. Until now.

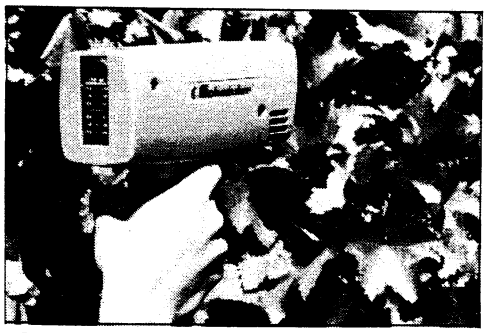
Enology student Louis Moreau directs grapes through auger at university research winery.

Like many other industries of varying types and sizes, the state's wine industry is finding itself under stricter air emissions control standards set by the California Air Resources Board (ARB), noted CSU, Fresno enology professor Carlos Muller, principal investigator for the project. Under a tiered implementation program established by the ARB to reduce ethanol emissions, large wineries soon may be required to capture and contain ethanol and other elements that until now have been allowed to escape into the atmosphere during the fermentation process.

Ethanol vapor, together with other hydrocarbons released into the

See ***Ethanol****, page 3*

Project aim is to set stress standards



Standard Oil's infrared thermometry gun.

The fine art of winemaking is a task most grape growers have traditionally left in the hands of the commercial wine industry. With the grower supplying the best quality grapes he or she can, it's been up to the winemaker to transform the juice into an attractive, palate-pleasing beverage.

However, with the advent of more sophisticated techniques for measuring water stress levels in grape vines, growers soon may play a greater role in determining the quality of wines, according to an irrigation specialist conducting research for CSU, Fresno's Viticulture and Enology Research Center (VERC).

Stressing, or reducing water supplies to grape vines, can affect

See ***Stress****, page 3*

Ethanol

from page 1

air, contributes to the formation of smog, ARB officials say.

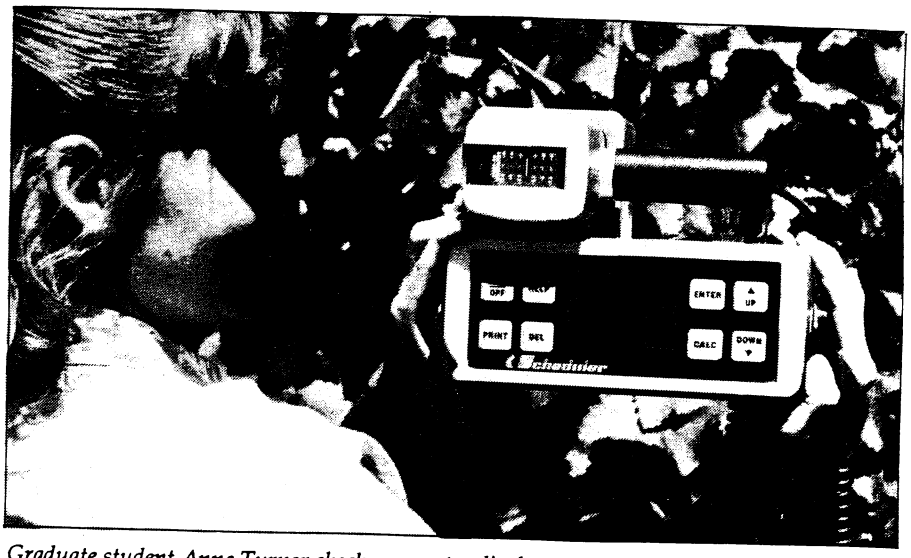
Large-scale winemakers have expressed willingness to abide by the new regulations, Muller said. But they are concerned about the high costs of the equipment that would have to be installed. The larger wineries, some of which use dozens of large tanks for fermentation, would have to install control equipment on virtually every tank. And because of the regulations and materials required, the control device "could end up costing more than the tank," Muller said.

In an effort to bring a positive side effect to the requirements, Muller proposed the idea of injecting the captured volatiles back into the wine. "Many of these constituents are flavor components which, if trapped instead of being lost to the atmosphere, might be useful in enhancing the quality of the wines," Muller said. "We will be seeing if we can improve the quality of the wine and therefore make it a more saleable, more acceptable product." If it could draw a higher price, "a liability might be turned into a profit," he said.

The equipment for capturing the volatiles is in place at the university winery. This year's project will test a process for removing the volatiles from a charcoal filter as well as injecting them back into the wine. Samples of the wine will be ready for tasting late next spring.

The requirements for controlling ethanol emissions will be primarily a "big wineries" problem, since ARB regulations will call for controls only on large tanks, those that hold 50,000 gallons or more.

Funding for the project has been provided by the California Agricultural Technology Institute (CATI), with technical support and some materials being provided by area wineries. For more information call Muller at (209) 294-2089.



Graduate student Anne Turner checks computer display screen of infrared thermometry gun.

Stress

from page 1

sugar and acid content, as well as other fruit qualities, noted professor Charles Krauter. But without accurate instruments for measuring plant stress levels, it is difficult to plan irrigations which will bring the desired results.

Enter the Crop Water Stress Index (CWSI), an irrigation management tool that has enjoyed rapid technological advances over the last decade. The index is a formula for determining a plant's stress level by evaluating leaf temperature (an indication of the rate of water evaporation) in relation to air temperature and relative humidity.

> *"If we're going for the kind of precision we're after, we can't use the same formula for Thompson seedless that we're using for cabernet sauvignon."*

During the last three years Standard Oil Co. has incorporated several heat and humidity-measuring instruments into a prototype infrared thermometry "gun" that can measure the different variables simultaneously. Readings are then entered into a computer and factored to produce a water stress reading.

But still there is more calibration work to do. Since different plants interact differently with the environment, individualized formulas need to be developed to accurately measure stress levels of various crops. Krauter said grapes present the greatest challenge because of the large number of varieties grown and the different traits desired, especially for winemaking.

The industry is interested in obtaining specialized stress-measuring formulas for groups of similar varieties and perhaps even for individual varieties, Krauter said. "If we're going for the kind of precision we're after, we can't use the same formula for Thompson seedless that we're using for cabernet sauvignon."

As part of a three-year project funded by CATI and the American Vineyard Foundation, Krauter has begun efforts to calibrate water-stress formulas for 27 wine, raisin and table grape varieties.

The varietal plots are within the university vineyards. Drip irrigation will be used to stress the plants to various degrees at different growth stages. CSWI reference values for each variety will be calibrated this year, then further refined during later phases of the project.

Record-keeping software upgraded

An electronic "Green Book" for farmers has been made more powerful but still easy to use through the work of an agricultural economics specialist at California State University, Fresno.

Professor James Cothern recently completed revisions of the farm record-keeping program, Turbo Farm, enhancing its speed and flexibility without making it more difficult to use.

Turbo Farm 3.0, like its predecessors, is patterned after the "Green Book" many farmers have traditionally used for record keeping. The program can be used to chart income and expenses, enterprise information, land listings, chemical use, depreciation information, inventory, net worth, and reports on farm profit.

Since joining the CSU, Fresno faculty earlier this year, Cothern has upgraded the program by adding capacity for a greater number of financial accounts and enterprises and a module that performs budget and cash flow analysis. He and fellow professor David Smith plan to further upgrade the program this year by adding additional accounting modules, including a whole-farm analysis module, and by producing a training manual.

Funding for the project has been provided by CATI and UC Davis. For details contact Cothern at (209) 294-2949.

Calendar

October

21 Computer workshop:

The fall series of Lotus workshops continues with intermediate and advanced sessions on agribusiness management applications of Lotus 1-2-3. The October 21 workshop will be Intermediate Lotus 1-2-3 Commands. Registration deadline is October 6. Fee is $150. On November 18 two half-day sessions are planned: The morning workshop will be Advanced Lotus: Databases, from 9 a.m. to noon. The second session will be Advanced Lotus: Macros, from 1 to 4:30 p.m. Fee for each advanced workshop is $75. For registration details call (209) 294-4869.

November

8-10 Farm show:

One of the winter season's first farm shows, AgFRESNO, will be held at the Fresno Fairgrounds. The show features displays of farm equipment, as well as seminars and a landscape and irrigation section.

Publications available

☐ **A Method to Reduce Ethyl Carbamate Levels in Peach Distillates,** *by K.C. Fugelsang and C.J. Muller – Viticulture and Enology Research Center*

Contains the results of experiments of ethyl carbamate (urethane) in alcoholic beverages. In one experiment, researchers examined the potential for reducing concentrations of ethyl carbamate in fermented distilling material before distillation. A second study focused on lowering compound 191 levels in peach alcohol. CATI Publication #890102.

☐ **Equipment Investment Analysis,** *by Dennis L. Nef – Center for Agricultural Business*

Offers guidelines for the use of a Lotus 1-2-3 spreadsheet template in analyzing equipment investments. Using the template, farm equipment managers are able to define and analyze factors affecting machinery costs, to specify parameters limiting the changes in such factors, and to analyze the range of possible choices that result. CATI Publication #880405.

Ordering Information:

Check the publication(s) and mail form to:
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Update

#891001 • October, 1989
Update is published monthly by the California Agricultural Technology Institute (CATI), School of Agricultural Sciences and Technology, CSU • Fresno 93740-0115.

Voice number: (209) 294-2361
Fax number: (209) 294-4849
ATI-Net Access Numbers:
300/1200 baud: (209) 294-4265
1200/2400 baud: (209) 294-4615

Director: Jon Shaver
Contributing Editors: Steve Olson, Lyn Bayless
Graphic Artist: Janet Pohl
Production Mgr: Cynthia Dondero

Non-Profit Organization
U.S. Postage
PAID
Fresno, CA
Permit No. 262

CALIFORNIA AGRICULTURAL TECHNOLOGY INSTITUTE
School of Agricultural Sciences & Technology
California State University • Fresno
Fresno, California 93740-0115

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Standard Oil Engineered Matls.
P.O. Box 391316
Solon OH 44139-0000